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Q1 a) i) $G(s) = \dfrac{K(s+3)}{(s+4)(s^2+2+j1)(s+2-j1)}$

ii) $\sigma_a$

iii)

b) i) $\%OS = 10$, $\xi = 0.59$, $\omega_n = 4.08\ rad/s$

$\theta = \cos^{-1} 0.59 = 53.84°$

$s_1 = -2 + j2.6$ $\quad s_1 = -2 + j2.6$

$s_2 = -2.4 + j3.2$ $\quad s_2 = -2.4 + j3.2$

ii) $K_1 = \dfrac{(1.6)(\sqrt{2^2+2.6^2})(3.6)}{(\sqrt{1^2+2.6^2})} = \dfrac{18.89}{2.79} = 6.77$

$K_2 = \dfrac{(\sqrt{0.4^2+2.2^2})(\sqrt{3.2^2+1.6^2})(\sqrt{0.4^2+4.2^2})}{(\sqrt{3.2^2+0.6^2})} = \dfrac{(2.24)(3.58)(4.22)}{3.26}$

$= 10.38$

iii) $CLTF = \dfrac{K(s+3)}{(s+4)(s+2+j1)(s+2-j1)+K(s+3)} = \dfrac{K(s+3)}{(s+4)(s^2+4s+5)+K(s+3)}$

Charac. eqn: $s^3+8s^2+(21+k)s+20+3k$ $= \dfrac{K(s+3)}{s^3+4s^2+5s+4s^2+16s+20+K(s+3)}$

for $k = 6.77$ : $s^3+8s^2+27.77s+40.31$ $= \dfrac{K(s+3)}{s^3+8s^2+(21+k)s+20+3k}$

third dom. pole : $-3.28$ $\quad \dfrac{3.28}{2} = 1.64 < 5$

$\therefore$ not valid

for $k = 10.38$ : $s^3+8s^2+31.38s+51.14$

third dom. pole $= -3.19$ $\quad \dfrac{3.19}{2.4} = 1.33 < 5$

$\therefore$ not valid

Q1 b) iv) $\tau_{s_1} = \frac{4}{\text{real}} = \frac{4}{2} = 2s$ $\tau_{s_2} = \frac{4}{2.4} = 1.67$

$\tau_{p_1} = \frac{\pi}{\text{Img}} = \frac{\pi}{2.6} = 1.21$ $\tau_p = \frac{\pi}{3.2}$ 0.98

$$K_p = \lim_{s \to 0} G(s) = \frac{K(s+3)}{(s+4)(s+2+j1)(s+2-j1)}$$

$$\text{for } K_{p1} = \frac{6.77(3)}{(4)(2+j1)(2-j1)} = 1.02$$

$$\text{for } K_2 = \frac{10.38(3)}{(4)(2+j1)(2-j1)} = 1.56$$

$$e_{ss1} = \frac{1}{1+1.02} = 0.495 \qquad e_{ss2} = \frac{1}{1+1.56} = 0.39$$

Q 2

$$G(s) = \frac{K(s^2-2s+8)}{(s+3)(s^2+4s+5)} \qquad s_d = -0.88 \pm j1.72 \quad 20\%\ OS$$

a) $T_{s\,old} = \frac{4}{0.88} = 4.545$

$$\zeta = \frac{-\ln 0.2}{\sqrt{\pi^2 + \ln^2 0.2}} = \frac{1.61}{3.53} = 0.456$$

$$\cos^{-1} 0.456 = 62.9^\circ$$

$$T_{s\,new} = 4.55 \times \frac{3}{5} = 2.73$$

$$G_{PI} = \frac{K(s+0.1)}{s} \qquad G_{PI}G(s) = \frac{K(s^2-2s+8)(s+0.1)}{s(s+3)(s^2+4s+5)}$$

$$T_{p\,old} = \frac{\pi}{1.72} = 1.83$$

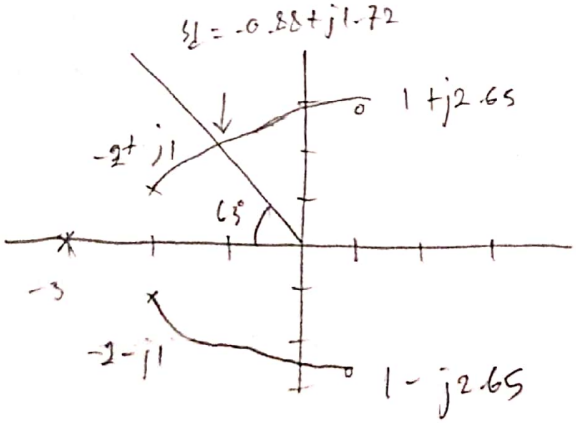
$$K = \frac{\sqrt{1.12^2+0.72^2}\,\sqrt{1.12^2+2.72^2}\,\sqrt{2^2+1^2}}{\sqrt{1.88^2+0.43^2}\,\sqrt{1.88^2+4.37^2}} = \frac{(1.33)(2.94)(1.41)}{(2.097)(4.76)} = 0.55$$

$$G_{PI} = 0.55\left(s + \frac{K_I}{K_P}\right) \qquad 0.1 = \frac{K_I}{0.55}$$

$$K_I = 0.055$$

$$G_{PI}G(s) = \frac{0.55(s+0.1)K(s^2-2s+8)}{s(s+3)(s^2+4s+5)}$$

b)

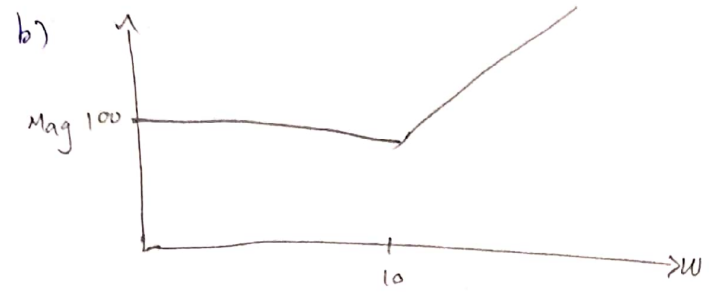


Q3 a) i) $G(s) = \dfrac{|s| \cdot |s+6|}{|12|}$ $20 \log k$

ii) $G(jw) = \dfrac{12}{jw\,(jw+6)} = \dfrac{12}{j20\,(j20+6)} = \dfrac{12}{(-400)(j120)}$

$= j\,2.5 \times 10^{-4}$

b)





c)